other point which was discussed was the importance of location, and by a few striking illustrations Mr. Sheets showed the startling savings in operation cost which could be effected by proper location. In one specific case in Illinois where a road some 150 miles in length was relocated almost entirely throughout its length, 31 grade crossings and 30 miles of unnecessary distance were eliminated. The saving in operation to the motorists of that State resulting from the proper location of this one highway may be estimated most conservatively at $20,000,000 in a 20-year period.

ROAD DRAINAGE

By William Tonkel,
Allen County Highway Superintendent.

The importance of good drainage in the economic maintenance of highways cannot be too greatly emphasized. There are two forms of road drainage—natural and artificial.

Natural drainage is that offered by the contour of the land and the condition of the sub-soil. Sub-soil such as sand and gravel will in places provide excellent drainage, and in some places such natural conditions afford so perfect a drainage system that very little artificial drainage will be needed beyond the customary crown and shallow side ditches.

Artificial drainage is secured by the crown of the road, side ditches and sub-drains. The crown and side ditches provide the surface drainage, and the side ditches and sub-drains serve to drain the roadbed.

Many auxiliaries are frequently necessary to proper drainage, such as culverts, catch basins, French drains, paved gutters, inlets, etc. The amount of artificial drainage required will at all times depend upon the existing natural drainage.

A road surface should have a crown sufficient to drain the surface water from the road to the side ditch. It should not be so excessive as to drain the water too rapidly, thereby eroding the shoulders. An excessive crown will encourage the traffic, in order to prevent slipping, to track in the center of the road. The crown should be slightly greater on grades of 5% or over than on level grades.

Side ditches should be deep enough so that the surface of the water is well below the base of the metal and should be kept absolutely free from any loose earth or other rubbish

which may drop into them. The depth of side ditches depends upon the contour of the land and the condition of the soil itself. For ordinary purposes the bottom of the side ditch should be about 2½ feet below the crown of the road. In soils that drain very poorly and where spring water is encountered, side ditches, 2½ and 3 feet deep, with underdrains, may be required.

Underground Drains

Where the road goes through a cut, and in soil that drains very poorly, it may be necessary, in order to secure proper drainage, to install under-drains.

It is usually desirable to keep the pipe drains from beneath the metal surface for the following reasons:

1. The soil is more porous underneath the side ditch than it is ordinarily underneath the road surface, and hence the water will have greater access to a drain under the side ditch.
2. The excavation into the sub-grade when the road is built will weaken the sub-grade, frequently causing defects to develop in the road later on.
3. If the drain becomes clogged or is broken in any way, it is more difficult to repair when beneath the road metal.

Of course occasionally, it is necessary to keep the subdrainage beneath the road metal, as illustrated by the following:

1. When the water reaches the road surface on a steep grade, by flowing from some higher elevation and parallel to the road.
2. Where the water comes up from underneath the roadbed as a spring. In such cases it may be necessary to construct a number of sub-drains before the source of all such water is reached.

Weeds should be cut to within two inches of the soil and kept neatly trimmed at all times of the year. The cuttings should be raked clear of the shoulder and ditch so as to avoid possibility of getting onto the surface and creating a soggy, slippery, dangerous hazard.